TECHNICAL MANUAL

QUALITY CONTROL OF COMPRESSED AND LIQUID BREATHING AIR

(ATOS)

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INTRODUCTION

1. PURPOSE.

This technical manual provides guidance, standards, methods, procedures, and safety instructions for establishing and maintaining quality at Air Force bases over compressed and liquid breathing air intended for human consumption in an environment having a contaminated or insufficient air supply.

1.1 Scope. To achieve the purpose, quality control at the AF base must be exercised over receipt of compressed and liquid breathing air from commercial sources (on- or off-base) and over generation, transportation, transfer, and storage being accomplished by AFB personnel.

1.2 Generally, the requirements of this manual apply to air produced by compressors which develop pressures of 100 psi or more. This manual does not apply to air pumps which typically develop about 15 psi and are not oil lubricated. Air pumps have a filtration system and do not require carbon monoxide alarms, high temperature alarms, additional filtration, or sampling when the pump inlet is located in a source of clean air.

1.3 The guidance provided in this technical manual is the minimum needed to be followed by AF bases. It meets the requirements of Grade D of ANSI/CGA G7.1, Commodity Specification for Air, as specified by OSHA and conforms to the National Fire Prevention Association document, NFPA 1500.

CHAPTER 1
GENERAL

1.1 QUALITY CONTROL REQUIREMENTS.

The requirements for exercising quality control by the AF include proper tools (sampling and testing equipment, adequate instructions, adequate laboratory facilities, etc.) and qualified personnel. Only capable personnel who have received adequate instructions to accomplish the work involved shall be assigned.

1.2 DEFINITION OF QUALITY CONTROL.

Quality control is that management function by which the conformance of material to established standards is assured; the quality and reliability of material is measured; and in the event of defects, corrective action is effected.

1.3 RESPONSIBILITIES.

Fulfilling the AF Quality Control Program as it affects base generation, receipt, storage, and handling of compressed breathing air requires the joint efforts of personnel performing in the areas of supply, maintenance, and engineering in collaboration with procurement personnel having cognizance over the contractor.

1.4 HEALTH AND SAFETY CONSIDERATIONS.

In cases of mishaps or complaints from the user, i.e., bad odor, where breathing air is suspected of being the factor, the local Director of Base Medical Services and/or Safety Office will be contacted. The Director of Base Medical Services personnel will assist in investigation of the complaint and aid in obtaining samples for analysis for submission to a laboratory selected according to Paragraph 2.29.

CHAPTER 2
QUALITY CONTROL OF COMPRESSED BREATHING AIR

2.1 INTRODUCTION.

The quality control of compressed breathing air requires continuous surveillance. Surveillance begins with procurement or Air Force generation and continues throughout storage, handling, transfer, and servicing of the equipment. To assure mission completion, adequate and reliable quality control of compressed breathing air must be performed during each operation. This technical order is to be used in conjunction with T.O. 00-25-235, T.O. 42B5-1-2, and the applicable T.O.s for self-contained or air-line breathing equipment and compressors. When reference is made to cylinders in this T.O., it applies to all cylinders used to contain compressed breathing air, that is, storage and self-contained breathing apparatus cylinders.

2.2 PERSONNEL.

Personnel selected to perform operations in the supply system shall be trained in a thorough knowledge of the characteristics of breathing air, the effects of contamination when used for breathing purposes, and the supply system. Only those personnel who demonstrate understanding of the operations involved, and who are capable and reliable, shall be assigned duties and responsibilities in the supply system.

2.3 OCCURRENCE.

WARNING

It is the oxygen in the air that we breathe which keeps us alive. Nitrogen, argon, and other pure gases (except oxygen) do not contain oxygen and breathing them will cause unconsciousness and finally death. We must use these gases with care. This is because the release of large amounts in a closed space will flush oxygen away making life impossible without a supplied air respirator.

The atmosphere is the usual source for obtaining compressed breathing air by direct compression. An alternate method is by mixing compressed nitrogen and oxygen in the proper ratios as is frequently done by industry. The approximate composition of atmospheric air by volume is 78.1% nitrogen; 20.9% oxygen; the remaining 1.0% consists of mostly argon, carbon dioxide, water vapor in various amounts, and traces of gases, such as neon, helium, carbon monoxide, nitrogen oxides, krypton, and xenon.

Table 2-1. Use Limits

Component	Source I Pressurized Cylinder	Source II Compressor
Oxygen % by vol	20 – 23	20 – 23
Carbon Dioxide ppm by vol	1000	1000
Carbon Monoxide ppm by vol	10	10
Gaseous Hydrocarbons (as methane) ppm by vol max	25	25
Halogenated Solvent ppm by vol max	0.2	0.2
Water Vapor ppm by vol max[1]	24	Report[2]
Condensed Oil and Particulate Matter mg/m[3] max	5	5
Odor	No Pronounced Odor	No Pronounced Odor
Other[3]	None Detected	None Detected

[1] See Paragraph 2.12, Step a (3) for information on cylinder selection for sample submission.

[2] The dew point of compressed breathing air used with supplied-air respirators shall be lower than the lowest ambient temperature to which any regulator or control valve on the respirator or air supplied system will be exposed. See Paragraph 2.7, Step d for converting water vapor concentration to dew point.

[3] Nitrous oxide is excluded from this requirement. Nitrous oxide is always present in atmospheric air, is not controlled by this technical manual, and is not reported.

2.4 NOMENCLATURE.

The official nomenclature of the product, classified in FSC 6830, is air, compressed, for breathing purpose, Source I (pressurized container) and Source II (directly from a compressor).

2.5 INTENDED USE.

The compressed breathing air covered by this technical order is intended for use by personnel in environments having a contaminated or insufficient air supply such as propellant handlers, tank cleaning, fire departments, disaster control, and scuba diving.

a. Source I is used in applications that require the use of any self-contained supply of air for breathing.

b. Source II is used in applications that require a direct supply (air-line) of breathing air from a compressor.

2.6 CONTAMINATION OF COMPRESSOR SYSTEMS.

Air compressor systems (including regulators, filters, valves, and piping) may become contaminated when they are used to pressurize tanks containing chemicals. The cause of the contamination is flow or diffusion of the chemical from the tank back through the line connecting it with the compressor system. If a system which has been contaminated in this manner is used to provide breathing air, the contaminant will be picked up by the flow of air and carried into the compressed breathing air cylinder or to the air-line respirator.

a. An air compressor system which has been used to pressurize chemical tanks shall not be used as a source of breathing air until an analysis of the air produced shows that it is not contaminated.

b. When requesting an analysis, of the kind described above, fill out an AFTO Form 182 in accordance with Paragraph 2.12, Step b except for the following:

(1) In the block identifying the REASON FOR ANALYSIS, mark the square OTHER and enter POSSIBLE CONTAMINATION.

(2) Mark the square SEE NOTES and on the reverse side of the form write the name of the chemical with which the compressor system may have been contaminated.

c. An air compressor system should not be used for pressurizing both chemical tanks and breathing air systems (cylinder or air-line respirators). In most cases, the recommended pressurant for chemical tanks is an inert compressed gas such as technical nitrogen conforming to Specification A-A-59503.

2.7 REQUIREMENTS.

a. Procurement Limit – compressed breathing air procured from a commercial source must meet the requirements of Federal Specification BB-A-1034.

b. Use Limits – see Table 2-1.

c. The balance of product shall consist of nitrogen and, if present, the usual quantities (or less) of other gases usually found in the atmosphere.

d. Dew Point (See Figure 2-1.) – line up a ruler or other straight edge with the pressure scale and the water vapor scale using the values for your system or system component. Read the dew point where the ruler crosses the dew point scale. For example, if your system pressure is 100 psig and the water vapor content from the last sample is 50 ppm then the lowest acceptable temperature, the dew point of the system, is –22°F.

2.8 SOURCES OF COMPRESSED BREATHING AIR.

Compressed breathing air for Air Force use obtained from commercial sources will meet the requirements in latest revision of Compressed Gas Association Specification CGA G-7.1, Grade D.

a. Compressed breathing air obtained from Government-owned/Government-operated sources must meet requirements of Table 2-1.

b. Normally, the air supply cylinder contains about 300 cubic feet of pure breathing air. Cylinders may be manifolded together for greater air supply for hoseline supplied equipment, or for cascading to fill self-contained breathing equipment. (Reference Paragraph 2.18.)

2.9 HUMIDIFICATION.

Personnel who are breathing extremely dry air may experience discomfort. Breathing air may be humidified between the air supply regulator and the respirator (low-pressure side of the air supply system). Where ambient temperatures are below freezing, humidification must be done carefully so condensation does not occur and lead to air-line freeze-up or fogging of the respirator faceplate.

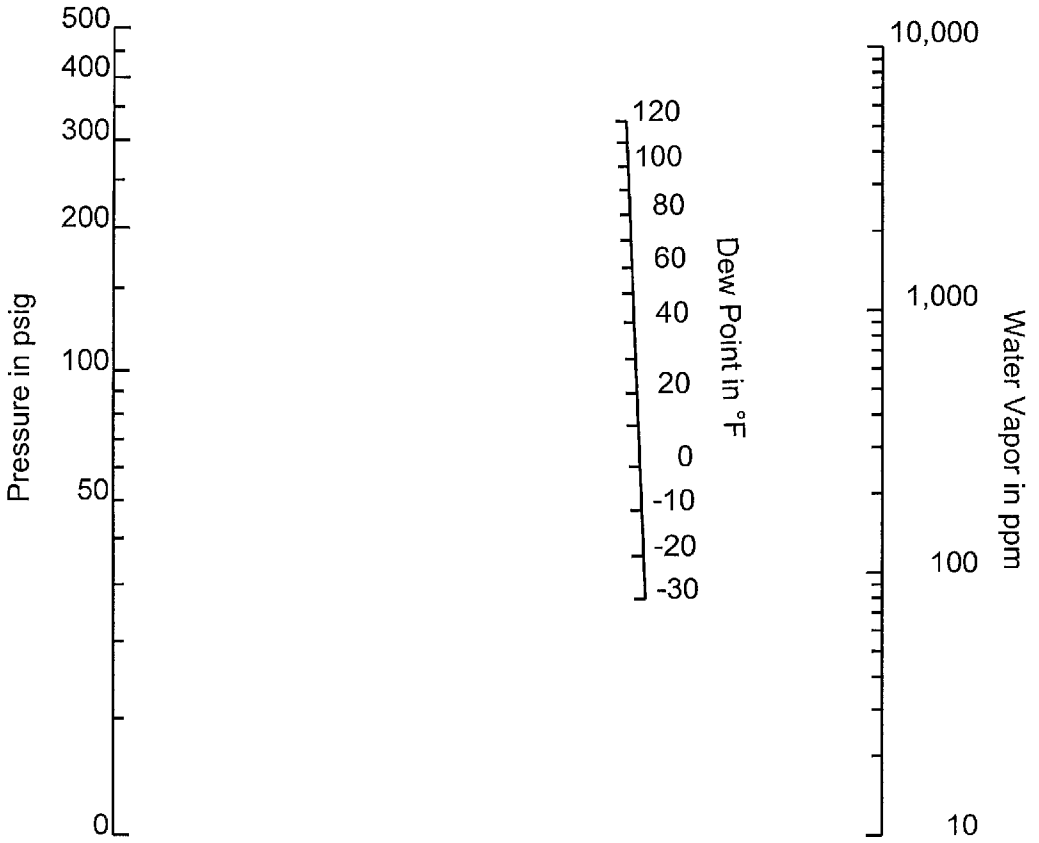

Figure 2-1. Nomogram for Dew Point Determination

2.10 ON-BASE TESTING.

a. Compressed breathing air cylinders filled at Air Force filling locations shall be tested for odor as follows:

(1) Sampling Location – cylinder valve with regulator.

(2) Frequency – test contents of each filled cylinder.

(3) Method – turn on the regulator cautiously and smell the slowly escaping gas.

b. Compressed breathing air used for air-line operation shall be tested for odor as follows:

(1) Sampling Location – at the face mask.

(2) Frequency – immediately before use.

(3) Method – smell air coming into mask from source.

c. Carbon Monoxide – carbon monoxide alarms shall be installed on all compressor systems used to produce compressed breathing air.

(1) Location – the carbon monoxide alarm shall be located between the purifier and the filling manifold or air-line respirator.

(2) Calibration – the carbon monoxide alarm shall be set at 10 ppm. Per T.O. 33K-1-100-1, the user shall perform an operational check using a standard gas before use. The operational check may be performed using room air if the operator's manual for the alarm indicates that it is an acceptable method of calibration. If the instrument is used several times in a 24-hour period, one operational check per day is sufficient. If the instrument is permanently mounted and in continuous use the operational check shall be performed in accordance with the applicable maintenance manual, or once a day. PMEL will calibrate the instrument every six months or more frequently as recommended by the manufacturer, but not less than every three months. Maintenance will be performed by PMEL as required.

2.11 Refer to Paragraph 2.21 if a sample fails any on-base test.

2.12 PERIODIC TEST FOR PURITY, KINDS, AND AMOUNTS OF CONTAMINANTS, CONDENSED OIL, AND PARTICULATE MATTER.

The following requirements apply to compressor systems used to produce compressed breathing air. A compressor system consists of two components – a compressor and a purifier.

a. Sampling for purity and kinds and amounts of contaminants.

(1) Sampling Location – purifier outlet, filling manifold, air-line connection, or a cylinder filled from the system.

(2) Frequency – the compressor system shall be sampled before initial use, after replacement of the compressor, the purifier, or after other major repairs, and once every 90 days.

(3) Sample Cylinders and Pressure – sample cylinders shall be pressurized to 100 psig minimum and shall be filled to their rated pressure when possible. For compressed breathing air samples, a full size SCBA tank should be used for submitting samples to the area lab. The smaller emergency cylinders contain insufficient amounts of compressed air to analyze the sample for moisture content.

b. Sample Identification – AFTO Form 182, Compressed Breathing Air Sample, shall be used to identify the sample and the filters. Complete 2 forms in duplicate as described below. Attach 1 to the sample cylinder and include the other within the filter packaging.

(1) Fill in all information on the AFTO Form 182 except the upper part marked FOR LAB USE ONLY.

(2) In the block, Reason for Analysis, mark an X in the appropriate square.

(3) Contact local Bio-Environmental Engineering Services (BES) office to obtain a compressed breathing air sample number. This number shall be documented on the AFTO Form 182 for base and laboratory reference.

(a) Periodic – 90-day sample.

(b) Initial Use – sample before initial use.

(c) Major Repairs – sample after major repairs to compressor units.

(d) Resample – sample submitted due to failure of previous sample.

c. Sample Cylinder Packaging – suitable packaging is required to protect the cylinder during shipment. See Paragraph 2.15, Step a for a shipping box which may be used. Packagings with large amounts of wear or damage are not acceptable. Inspect and replace them when needed to make sure of prompt shipment to and from the laboratory.

d. Sampling for Condensed Oil and Particulate Matter.

(1) Method – use Air Systems International test module, or equivalent, as needed for the sampling location selected. See Paragraph 2.15 for a description of components. Insure that the component can handle the pressure at the sampling location.

(a) Before sampling, place the matching filter in a plastic petri dish, secure the lid with tape and mark it with a C for control sample.

(b) After sampling, place the test filter in a plastic petri dish, secure the lid with tape and mark it with a T.

(c) Package the two petri dishes with one of the AFTO Forms 182 and send them to the laboratory.

WARNING

Ensure that the regulator is capable of handling maximum output pressure of the compressor.

(2) Alternate Method – the sampling location for this method is the purifier outlet or filling manifold. The sampling assembly (Figure 2-2) must be assembled of parts that can withstand the pressures involved. The filter holder is rated at 10,000 psi at the inlet; however, the flowmeter is rated at 100 psig. A suitable pressure regulator is required. The procedure is as follows:

(a) Assemble the high-pressure filter holder with a membrane filter.

(b) Place the matching filter in a plastic petri dish, secure the lid with tape and mark it with a C for control sample.

(c) Attach the high-pressure filter holder to the sampling location.

(d) Attach a suitable pressure regulator to the filter holder.

(e) Attach flowmeter to the pressure regulator.

(f) Find the time required to pass 500 liters (L) through the filter at the selected flow rate by using the following formula:

$$\text{TIME} = \frac{500\text{L}}{\text{FLOW RATE}}$$

Time is in minutes, and the flow rate is in liters per minute.

The flowmeter is calibrated in Standard Cubic Feet per Hour (scfh), to convert this flow rate to Liters per Minute (Lpm) use the following conversion:

1 scfh = 0.472 Lpm

For Example:

Set the flowmeter to 60 scfh, this is equal to:

60 scfh x 0.472 = 28.32 Lpm

To determine how long it will take to collect 500 liters of air:

500 liters/28.32 Lpm = 17.66 minutes

(g) Operate the system and collect the sample by using the calculated time of flow.

(h) Depressurize the system.

(i) Disassemble the filter holder and remove the membrane filter.

(j) Place the filter in a plastic petri dish, secure the lid with tape and mark it with a T.

(k) Package the two petri dishes with one of the AFTO Forms 182 and send them to the laboratory with the compressed air for analysis.

e. Tests and Methods – tests for all components listed in Table 2-1 shall be conducted using methods in current issue of MIL-STD-1564, Federal Specification BB-A-1034, CGA Specification G-7.1, and this manual. The test for OTHER components shall be accomplished according to MIL-STD-1564. Except for nitrous oxide, any OTHER component which is discernable from background noise on the infrared spectrum shall be cause for failure of the sample.

f. Laboratories – samples will be forwarded to a laboratory for testing according to Paragraph 2.29.

g. Test Reports – the laboratory shall send copies of the test report to the sample submitter and to DET 3, WR-ALC/AFTT, 2430 C St, Bldg 70, Area B, Wright-Patterson AFB, OH 45433-7632. The submitter shall provide a copy of the test report to the Bio-Environmental Engineering Services Office.

2.13 PREPARATION OF CONTAINER (SAMPLE CYLINDER) FOR SAMPLING PERIODIC TESTS.

When a sample cylinder contains compressed breathing air which is within the limits in Table 2-1, no additional preparation is necessary. When a sample cylinder contains compressed breathing air that exceeds the limits in Table 2-1, it shall be processed according to the applicable instruction manual.

2.14 CONTAINERS.

See T.O. 42B5-1-2 and the T.O.s for the applicable self-contained breathing equipment for cylinder requirements.

2.15 EQUIPMENT AND MATERIALS FOR SAMPLING AND TESTING.

a. Packaging.

NSN	Nomenclature	Test Method
8115-00-519-1825	Box, Shipping, PPP-B-636, Type 3, Style G	

b. Sampling Equipment for Condensed Oil and Particulate Matter.

NSN	Nomenclature	Test Method
—	Total Particulate Test Module – maximum 20 psig, Air Systems International, P/N LP- 47PF (See NOTE 1.)	Paragraph 2.12, Step d (1)
6640-00-159-2438	MF-Millipore (Mixed Esters of Cellulose) Membrane Filter, Matched Weight Pairs, Millipore, P/N AAWP 047-0M (See NOTE 1.)	Paragraph 2.12, Step d (1) and (2)
6640-00-989-1109	High-Pressure 316 Stainless Filter Holder, 47 mm, Millipore, P/N XX45 047 00 (See NOTE 1.)	Paragraph 2.12, Step d (2)

NSN	Nomenclature	Test Method
6680-01-439-8360	Flowmeter, 20 – 120 scfh, Brass Connectors and Valve, Matheson, P/N Q1-3E101-Q602 (See NOTE 1.)	Paragraph 2.12, Step d (2)
—	Inner O-Ring (preferred) Millipore, P/N XX4504710	Paragraph 2.12, Step d (2)
—	Outer O-Ring (preferred) Millipore, P/N XX4504713	Paragraph 2.12, Step d (2)

NOTE 1: To make a complete test kit you will either need the Air Systems International Total Particulate Test Module and the membrane filters, or the high-pressure filter holder, the flowmeter, and the membrane filters. A pressure regulator may be required with certain systems to reduce the pressure of the air entering the flowmeter or test module to less than 100 psig.

2.16 RECEIPT OF COMPRESSED BREATHING AIR FROM A CONTRACTOR.

Compressed breathing air is procured from contractors in cylinders of 200 – 300 cubic feet capacity or self-contained breathing apparatus air cylinders of approximately 5 – 40 cubic feet capacity. The material supplied by the contractor to the using activities must meet the requirements and quality assurance provisions and procedures of the specification and the supply contract. The requirements and provisions specify preproduction testing of the gaseous air, processing of cylinders before filling, tests on the contents of filled cylinders, marking and inspection by the Government Quality Assurance Representative at the contractor's filling plant. Upon receipt of product from a contractor, on-base sampling and testing of contents of the cylinders are not required; however, each cylinder shall be inspected for the following:

a. Proper painting and marking.

b. Valves are tightly closed.

c. Safety caps or safety plugs are leak-tight and secure.

d. Valves protective caps are installed.

e. Grease or oil on the valves or cylinders. Cylinders with grease or oil found on them shall be tagged immediately with the appropriate notation until the quality assurance representative takes action.

2.17 AIR FORCE-OPERATED FILLING LOCATIONS.

a. Before filling, each cylinder shall be processed in accordance with Paragraph 2.24.

b. Compressed breathing air shall be produced and filled (charged) into cylinders in accordance with the instructions of the applicable air compressor or liquid oxygen generating plant operation and service manuals.

c. Production and cylinder filling with compressed breathing air.

(1) Purge charging manifold and feed lines. Test air for odor at the manifold branch to which each cylinder is attached. If odor is detected, do not fill cylinders until corrective action is taken, and odor is no longer detected.

(2) Fill cylinders attached to the charging manifold as described in the applicable manual.

(3) Table 2-2 is provided for information only and demonstrates how the pressure will vary with the ambient temperature. For service pressures not listed in Table 2-2 contact DET 3, WR-ALC/AFTT at DSN: 785-8050 for a mathematical formula for calculating a cylinder's pressure at a given temperature.

2.18 RECHARGING SELF-CONTAINED BREATHING APPARATUS AIR CYLINDERS.

In recharging self-contained breathing apparatus tanks, the applicable apparatus technical order shall be referred to for service charging procedures.

2.19 INSPECTION AND PROCESSING OF DOT 3A AND DOT 3AA CYLINDERS FILLED AT AIR FORCE FILLING LOCATIONS.

Before removal to storage, each cylinder shall be inspected and processed as follows:

a. Leak Test – each cylinder shall be tested for leakage by brushing a leak test compound conforming to MIL-PRF-25567 over the junction between the valve and the cylinder and all portions of the valve, (except the valve outlet). Each cylinder shall be tested for leakage through the valve, when closed, by means of a tube from the valve outlet to a container of water. Care should be taken to insure that water or soap solution is not brought into contact with the valve outlet.

(1) Leaking Valves – cylinders found to leak through the valve or at the junction between the

valve and the cylinder shall be emptied to 0 psig by slightly opening the cylinder valve. When the pressure is reduced below the noise level, valves may be fully opened. All cylinders shall be bled in the open at a safe distance from any source of ignition. Ship empty cylinder to an authorized vendor for repair.

(2) Leaking Cylinders – cylinders found to leak through the cylinder wall are not suitable for refilling and shall be emptied to 0 psig and shall be processed in accordance with Paragraph 2.26.

b. Attach valve outlet (dust) cap.

c. Wire AFTO Form 407 bearing the following information, to the cylinder valve:

1. Filling Date _____.

2. Lot Number _____.

3. Odor Test PASS.

4. Leak Test PASS.

5. Final Filling Pressure _____.

6. Filling Location _____.

d. All tags, labels, and other markings shall be removed from EMPTY cylinders. The cylinder will be tagged with DD Form 1574 tag over-stamped with the letters MT to indicate that the cylinder is empty, but serviceable.

e. Attach valve outlet (dust) cap.

f. Screw valve protection cap securely on cylinders.

2.20 REJECTION DUE TO TEST FAILURES.

Rejection of a compressed air sample can occur at the base level, or at the area lab. The corrective action to be taken will depend upon the nature and severity of the problem.

2.21 ON-BASE TEST FAILURE.

a. When one cylinder or a small portion of cylinders charged from the same manifold at the same time fail the odor test, the cylinders are not suitable for use. The cylinders shall be rejected, emptied to 0 psig pressure and processed in accordance with Paragraph 2.25.1.

b. When all cylinders charged from the same manifold at the same time fail the odor test, the cylinders shall be rejected and emptied to 0 psig pressure and processed in accordance with Paragraph 2.25.1, before refilling. Do not fill any more cylinders until the cause and source of the odor has been determined and corrective action has been taken.

c. When the compressed breathing air from an air-line operation fails odor or carbon monoxide test, the compressor shall be shut down until the defective condition is corrected.

d. When a sample fails the test for condensed hydrocarbons, the compressor shall be shut down until the defective condition is corrected. Cylinders filled from this compressor shall be inspected internally and cleaned if necessary. See MIL-STD-1411, Inspection and Maintenance of Compressed Gas Cylinders, for inspection and cleaning procedures.

2.22 PERIODIC SAMPLE TEST FAILURES.

When the compressed breathing air fails the requirements in Table 2-1, immediate corrective action will be taken.

2.23 PROCESSING EMPTY DOT 3A AND DOT 3AA CYLINDERS TO BE RETURNED FOR REFILLING.

Prior to shipping EMPTY cylinders for refilling, each cylinder shall be inspected and processed as follows:

a. Insure that cylinders are emptied to less than 25 psig pressure but not less than 5 psig. If the pressure of the cylinder has been released below 5 psi, do not re-pressurize the cylinder. Close the valve, if open, and continue processing the cylinder for refilling.

b. All tags, labels, and other markings shall be removed from EMPTY cylinders. The cylinder will be tagged with DD Form 1574 tag over-stamped with the letters MT to indicate that the cylinder is empty, but serviceable.

c. Attach valve outlet (dust) cap.

d. Screw valve protection cap securely on cylinders.

e. Cylinders shall be transported in a vertical position (where design permits) secured in a manner that will prevent movement that may damage the cylinder or its painting or marking.

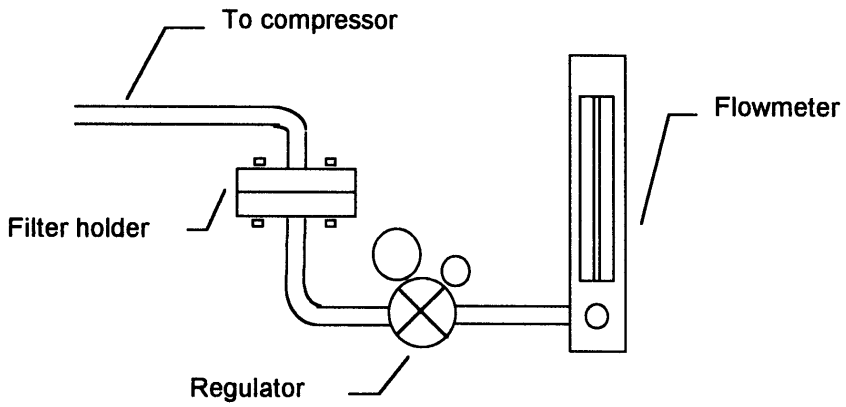

Figure 2-2. Oil and Particulate Sampling Assembly

Table 2-2. Pressure Temperature Conversion Chart

Settled Temperature °F	Type I Container Service Pressure (expressed in psig)					
	1800	2000	2200	2265	2400	4500
–50	1267	1396	1523	1564	1649	2882
–48	1276	1406	1534	1576	1662	2909
–46	1285	1416	1546	1588	1674	2936
–44	1293	1426	1557	1600	1687	2963
–42	1302	1436	1569	1611	1700	2990
–40	1311	1447	1580	1623	1712	3018
–38	1320	1457	1592	1635	1725	3045
–36	1329	1467	1603	1647	1738	3072
–34	1338	1477	1614	1659	1750	3099
–32	1347	1487	1626	1670	1763	3126
–30	1356	1497	1637	1682	1776	3154
–28	1365	1508	1648	1694	1788	3181
–26	1374	1518	1660	1706	1801	3208
–24	1383	1528	1671	1718	1813	3235
–22	1392	1538	1683	1729	1826	3262
–20	1401	1548	1694	1741	1839	3290
–18	1410	1558	1705	1753	1851	3317
–16	1419	1568	1717	1765	1864	3344
–14	1428	1578	1728	1776	1876	3371
–12	1437	1589	1739	1788	1889	3398
–10	1446	1599	1751	1800	1901	3426
–8	1455	1609	1762	1811	1914	3453
–6	1464	1619	1773	1823	1927	3480

Table 2-2. Pressure Temperature Conversion Chart - Continued

Settled Temperature °F	Type I Container Service Pressure (expressed in psig)					
	1800	2000	2200	2265	2400	4500
–4	1472	1629	1784	1835	1939	3507
–2	1481	1639	1796	1847	1952	3534
0	1490	1649	1807	1858	1964	3562
2	1499	1659	1818	1870	1977	3589
4	1508	1669	1830	1882	1989	3616
6	1517	1679	1841	1893	2002	3643
8	1526	1689	1852	1905	2014	3670
10	1535	1699	1863	1917	2027	3697
12	1544	1710	1875	1928	2039	3724
14	1552	1720	1886	1940	2052	3750
16	1561	1730	1897	1952	2064	3777
18	1570	1740	1909	1963	2077	3804
20	1597	1750	1920	1975	2089	3831
22	1588	1760	1931	1987	2102	3858
24	1579	1770	1942	1998	2114	3885
26	1606	1780	1954	2010	2127	3911
28	1615	1790	1965	2021	2139	3938
30	1623	1800	1976	2033	2152	3965
32	1632	1810	1987	2045	2164	3992
34	1641	1820	1998	2056	2176	4019
36	1650	1830	2010	2068	2189	4045
38	1659	1840	2021	2080	2201	4072
40	1668	1850	2032	2091	2214	4099
42	1676	1860	2043	2103	2226	4126
44	1685	1870	2055	2114	2239	4153
46	1694	1880	2066	2126	2251	4179
48	1703	1890	2077	2138	2264	4206
50	1712	1900	2088	2149	2276	4233
52	1721	1910	2099	2161	2288	4260
54	1729	1920	2111	2172	2301	4286
56	1738	1930	2122	2184	2313	4313
58	1747	1940	2133	2196	2326	4340
60	1756	1950	2144	2207	2338	4366
62	1765	1960	2155	2219	2350	4393
64	1774	1970	2166	2230	2363	4420
66	1782	1980	2178	2242	2375	4447
68	1791	1990	2189	2253	2388	4473
70	1800	2000	2200	2265	2400	4500
72	1809	2010	2211	2277	2412	4527

Table 2-2. Pressure Temperature Conversion Chart - Continued

Settled Temperature °F	Type I Container Service Pressure (expressed in psig)					
	1800	2000	2200	2265	2400	4500
74	1818	2020	2222	2288	2425	4553
76	1826	2030	2233	2300	2437	4580
78	1835	2040	2245	2311	2450	4607
80	1844	2050	2256	2323	2462	4633
82	1853	2060	2267	2334	2474	4660
84	1862	2070	2278	2346	2487	4687
86	1870	2080	2289	2357	2499	4713
88	1879	2090	2300	2369	2511	4740
90	1888	2100	2312	2380	2524	4767
92	1897	2110	2323	2392	2536	4793
94	1906	2120	2334	2404	2548	4820
96	1914	2129	2345	2415	2561	4846
98	1923	2139	2356	2427	2573	4873
100	1932	2149	2367	2438	2585	4900
102	1941	2159	2378	2450	2598	4926
104	1949	2169	2389	2461	2610	4953
106	1958	2179	2401	2473	2622	4979
108	1967	2189	2412	2484	2635	5006
110	1976	2199	2423	2496	2647	5032
112	1985	2209	2434	2507	2659	5059
114	1993	2219	2445	2519	2672	5086
116	2002	2229	2456	2530	2684	5112
118	2011	2239	2467	2542	2696	5139
120	2020	2249	2478	2553	2709	5165
122	2028	2259	2490	2565	2721	5192
124	2037	2269	2501	2576	2733	5218
126	2046	2278	2512	2588	2746	5245
128	2055	2288	2523	2599	2758	5271
130	2063	2298	2534	2611	2770	5298
132	2072	2308	2545	2622	2783	5324
134	2081	2318	2556	2634	2795	5351
136	2090	2328	2567	2645	2807	5377
138	2098	2338	2578	2657	2819	5404
140	2107	2348	2589	2668	2832	5430
142	2116	2358	2600	2680	2844	5457
144	2125	2368	2612	2691	2856	5483
146	2133	2377	2623	2702	2869	5510
148	2142	2387	2634	2714	2881	5536
150	2151	2397	2645	2725	2893	5562

2.24 PROCESSING OF EMPTY CYLINDERS RECEIVED AT AIR FORCE-OPERATED FILLING LOCATIONS.

Prior to refilling cylinders which have been received at Air Force-operated filling locations, each cylinder shall be inspected and processed as follows:

a. Inspecting and processing external condition and hydrostatic test date.

(1) Grease and Oil – any trace of grease or oil on the surface of a cylinder shall be removed before filling.

(2) Rust, Scale, Caked Paint, and Dirt – any loose rust, scale, caked paint, and dirt shall be removed so that the external surface can be adequately inspected.

(3) Dents, Cuts, Gouges, Digs, Bulges, Pitting, and Corrosion – each cylinder shall be inspected for the presence of these conditions. Inspection of the cylinder bottom is important because experience has shown this area is the most susceptible to corrosion. When any of the above conditions exist to the extent that the structural strength of the cylinder may have been weakened, it shall be rejected for filling. Depending upon the condition and its extent, the cylinder shall be tested for structural weakness or condemned and disposed of in accordance with Paragraph 2.26. Experience in the inspection of cylinders is a necessary factor in determining the acceptability of a cylinder for continued service. The removal of cylinders from service is therefore based on the experience and judgment of the inspector.

(4) Painting, Stenciling, and Marking – each cylinder shall be inspected for proper painting, stenciling, and marking as required by T.O. 42B5-1-2 and MIL-STD-101.

(5) Cylinder Valve Inspection – each cylinder valve shall be inspected for proper condition and functioning. If the valve is defective, install a new one in accordance with Paragraph 2.19.

(6) Hydrostatic Date Inspection for Steel Cylinders –each cylinder shall be inspected to determine the last date of hydrostatic testing. If the last date of testing was 5 or more years prior to the intended filling date, the cylinder shall be processed in accordance with T.O. 42B5-1-2. If the last date of testing was less than 5 years prior to the intended filling date, and the cylinder has passed all the requirements of Steps a (1) through (5), the cylinder shall be processed for filling in accordance with the following Steps b (1) and (2).

(7) Hydrostatic Date Inspection for Non-Steel Cylinders – non-steel cylinders have hydrostatic testing schedules that vary with the materials used to make the cylinders. See Table 2-5 for some basic guidelines for determining a cylinder's hydrostatic test date. Table 2-6 contains information on a variance to the fully wrapped carbon fiber cylinder's hydrostatic testing schedule. This chart is needed as early carbon fiber cylinders were given a 3 year hydrostatic cycle when they were first manufactured. Consult the cylinder manufacturer's literature if in doubt.

b. Inspecting and Processing Internal Condition.

(1) Positive Pressure and Odor Inspection – each cylinder shall be checked for positive internal pressure and odor. Unless a pressure gage is used to insure that a cylinder has at least a 5 psig internal pressure, a slip of paper shall be used to insure that any hissing sound, heard when the valve is cracked open, is due to a positive pressure rather than a vacuum. A cylinder with less than 5 psig pressure (or insufficient pressure to cause an audible hissing sound) or with an odor in the escaping gas shall be processed in accordance with Paragraph 2.25.1. If moisture is suspected, the cylinder shall be dried in accordance with Paragraph 2.25.1.

(2) Residual Gas Removal – a cylinder having positive pressure and no odor shall be evacuated to an absolute pressure of less than 3 inches of mercury and filled from this evacuated condition.

NOTE

When evacuation equipment is not available, dilution of the residual air in the cylinders can be obtained by releasing the residual air to the atmosphere and filling the cylinders to 150 psig with breathing air. The pressure is again reduced to atmospheric and the cylinders filled to the desired pressure.

2.25 DRYING MILD AND STAINLESS STEEL CYLINDERS.

WARNING

Heating cylinders to 350°F or more will weaken the aluminum metal. Repeated heatings at lower temperatures (greater than 150°F) may have the same effect. A weakened cylinder may explode during filling. Aluminum cylinders which have been heated or are suspected of having been heated shall be hydrostatically tested before filling (see T.O. 42B5-1-2).

Procedures in Paragraph 2.25.1 must not be used to dry aluminum cylinders. For assistance with regard to the drying of aluminum cylinders, contact DET 3, WR-ALC/AFTT.

2.25.1 Cylinders shall be dried by either the hot gas purging method or the evacuation method specified below. After filling, each cylinder dried by one of these methods shall be tested for odor, in accordance with Paragraph 2.10. If an odor is detected, the cylinder shall be rejected, emptied to 0 psig pressure and processed in accordance with Paragraph 2.26.

a. Hot Gas Purging Method – the cylinder shall be dried by removing the cylinder valve in accordance with Paragraph 2.19, inserting a tube extending approximately to the bottom of the cylinder; and passing clean, hot (400° – 500°F), dry, oil-free air through the air tube. At the end of the drying process, the cylinder valve shall be immediately installed in accordance with Paragraph 2.19, and closed.

b. Evacuation Method – the cylinder shall be dried by attaching a vacuum pump to the cylinder valve outlet, opening the valve, and heating the cylinder to approximately 180°F in an oven or hot-water bath while evacuating the cylinder to an absolute pressure of less than 3 inches of mercury. Maintain this vacuum on the cylinder until filling begins.

2.26 PROCESSING REJECTED CYLINDER.

Cylinders rejected or condemned for any reason as unsuitable for further use shall be processed in accordance with the requirements of T.O. 42B5-1-2.

2.27 INSPECTION AND TEST RECORDS.

Each Air Force-operated filling location shall maintain inspection and test records covering production, inspection, and processing of EMPTY cylinders, and inspection and testing of filled cylinders. Such inspection and test records shall include:

a. Inspection of filled cylinders (Paragraph 2.19).

1. Leak Test
2. Internal Inspection, Cleaning, and Replacement of Valves, if Required

b. Inspection of contents of filled cylinders (Paragraph 2.10).

1. Lot Number
2. DOT Serial Number of Each Cylinder in the Lot
3. Odor Test
4. Carbon Monoxide Test
5. DOT Serial Number of Each Sample Cylinder Selected from the Lot

2.28 ARMSTRONG LABORATORY.

The Armstrong Lab at Brooks City Base will provide guidance on compressed air contaminants that are not specifically addressed in this document. It is the responsibility of AFTT to contact and coordinate the disposition instructions with Armstrong Labs for those samples that contain unusual contaminants.

Armstrong Laboratory/OEAO
2402 E Dr.
Brooks City Base, TX 78235-5114
Telephone Numbers:
Commercial: (210) 536-3626
DSN: 240-3626

2.29 LABORATORIES.

Samples, except in two instances, shall be sent to a laboratory which is selected in this manner. Find the location of the submitting activity in Table 2-3 and note the number to the right of it. Find this number in Table 2-4 and the designated laboratory for the activity will be listed to the right along with addresses and telephone numbers. If the location of an activity is not listed, a request should be submitted to Wright-Patterson ALC/AFTH, 2430 C St, Bldg 70, Area B, Wright-Patterson AFB, OH 45433-7632, for a laboratory designation. Exceptions to this procedure follow:

a. Incident samples may be sent to any laboratory listed in this chapter.

b. Other laboratories may be approved by Wright-Patterson ALC/AFTH or in overseas areas by the Major Command.

Table 2-3. Laboratory Designations

Location	#	Location	#
Africa	4	Missouri	1 or 6
Alabama	1	Montana	3
Alaska	3	Nebraska	1 or 6
Arizona	3	Nevada	3
Arkansas	1 or 6	Netherlands	4
Azores	2	New Hampshire	2
Belgium	4	New Jersey	2
California	3	New Mexico	3
Colorado	3	New York	2
Connecticut	2	North Carolina	1
Crete	4	North Dakota	3
Delaware	1	Norway	4
Florida	1	Ohio	1
Georgia	1	Oklahoma	1 or 6
Germany	4	Oregon	3
Greece	4	Pacific	5
Greenland	2	Panama	1
Iceland	2	Pennsylvania	1
Idaho	3	Rhode Island	2
Illinois	1	South Carolina	1
Indiana	1	South Dakota	1
Iowa	1	Spain	4
Italy	4	Tennessee	1
Kansas	1 or 6	Texas	1
Kentucky	1	United Kingdom	4
Louisiana	1	Utah	3
Maine	2	Vermont	2
Maryland	1	Virginia	1
Mid-East	4	Washington	3
Massachusetts	2	West Virginia	1
Michigan	1	Wisconsin	1
Minnesota	1	Wyoming	3
Mississippi	1		

Table 2-4. Air Force Testing Laboratories

	Shipping Address	Mailing Address	Telephone Numbers
1	Aerospace Fuels Laboratory (FP2070) DET 3, WR-ALC/AFTLA 2430 C St, Bldg 70, Area B Wright-Patterson AFB, OH 45433-7632	Aerospace Fuels Laboratory DET 3, WR-ALC/AFTLA 2430 C St, Bldg 70, Area B Wright-Patterson AFB, OH 45433-7632	Commercial: (937) 255-2106 DSN: 785-2106
2	Aerospace Fuels Laboratory (FP2071) OL DET 3, WR-ALC/AFTLB Trundy Rd, Bldg 14 Searsport, ME 04974-0408	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLB P.O. Box 408 Searsport, ME 04974-0408	Commercial: (207) 548-2451
3	Aerospace Fuels Laboratory (FP2075) OL DET 3, WR-ALC/AFTLE 1747 Utah Ave, Bldg 6670 Vandenburg AFB, CA 93437-5220	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLE 1747 Utah Ave, Bldg 6670 Vandenburg AFB, CA 93437-5220	Commercial: (805) 606-6263 DSN: 276-2756
4	Aerospace Fuels Laboratory (FP2080) OL DET 3, WR-ALC/AFTLF – Bldg 725, Unit 5025 RAF Mildenhall, UK APO AE 09459	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLF Unit 5025 APO AE 09459-5025	Commercial: 44-1-638-54-2043 DSN: 314-238-2043/2797/ 5757
5	Aerospace Fuels Laboratory (FP2083) OL DET 3, WR-ALC/AFTLG – Bldg 854, Unit 5161 Kadena AB, Okinawa, JA APO AP 96368-5162	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLG Unit 5161 APO AP 96368-5162	Commercial: 011-81-611-734-1602/3394/ 0322 DSN: 315-634-3394/1602/3394/0322
6	OC-ALC/TIELA Attn: Chemical Sciences Section 3001 Staff Drive/STE I-63 Tinker AFB, OK 73145-3038	OC-ALC/TIELA Attn: Chemical Sciences Section 3001 Staff Drive/STE I-63 Tinker AFB, OK 73145-3038	Commercial: (405) 736-2135 DSN: 336-2135

Table 2-5. Hydrostatic Testing for Non-Steel Cylinders

Cylinder Type	Hydrostatic Testing	Life of Cylinder
All Aluminum (no hoops)	Every 5 Years	Indefinite[1]
Hoop-wrapped	Every 3 Years	15 Year Life
Fully Wrapped Fiberglass	Every 3 Years	15 Year Life
Fully Wrapped Kevlar	Every 3 Years	15 Year Life
Fully Wrapped Carbon Fiber[2]	Every 5 Years	15 Year Life

[1] The cylinder may be used until the cylinder fails hydrostatic testing.

[2] See Table 2-6 for variances to the carbon fiber wrapped cylinder's test schedule.

Table 2-6. Carbon Fiber Hydrostatic Testing Variances

DOT Exemption	Date of Manufacture (MM/YY) Retest After 3 Years	Date of Manufacture (MM/YY) Retest After 5 Years
DOT-E 10915	Pre 05/01[1]	05/01 and Later
DOT-E 10945	Pre 07/01[1]	07/01 and Later

[1] After the Pre 05/01 and 07/01 cylinders have been hydrostatically retested the first time, the re-inspection schedule changes to a 5-year cycle.

CHAPTER 3
HAZARDS AND SAFETY PRECAUTIONS IN HANDLING COMPRESSED BREATHING AIR

3.1 GENERAL.

The potential hazards in handling cylinders of compressed breathing air are due to the characteristics of air and to its confinement as a compressed gas. While air is noncombustible in itself, it supports the combustion of all flammable materials. As a compressed gas, the principal hazard is due to the rocket-like thrust imparted to the cylinder by the sudden and rapid escape of the gas. For example, if the valve of a cylinder at 2500 psig were broken off, the cylinder would have an initial thrust of about 2600-pound force. The cylinder could attain a velocity of 500 feet per second in about one tenth of a second. An additional potential hazard arises from the increase in pressure of the gas with any increase in temperature. Cylinders may explode or safety plugs may be blown out if the cylinders are exposed to higher than normal temperatures. Mechanical or structural damage may also cause failure of a cylinder. Compressed gas cylinders are built to withstand normal hard use but they must not be subjected to abuse. Serious accidents connected with their handling, use, and storage have invariably been traced to abuse or mishandling. All precautions outlined in this chapter must be exactly followed.

3.2 PRECAUTIONS IN HANDLING CYLINDERS.

a. Always close valves and replace caps when cylinders are not in use.

b. Handle cylinders carefully. Rough handling, knocks, or falls may damage the cylinders, valve, or safety devices and cause leakage. A more serious consequence could be a broken valve which could impart a rocket-like thrust to the cylinder by the rapidly escaping gas.

c. Never use cylinders for rollers, supports, or for any other purpose than to contain air.

d. Before making a connection to the cylinder valve, open slightly and close immediately. This action, called cracking, clears the valve of particles of dust or dirt that otherwise might enter the connection.

e. Never place hands or any part of the body in the path of the escaping airstream.

f. If a valve is difficult to open, point the valve opening away from the body and use greater force. Do not use a wrench or hammer. The average person can exert enough pressure with their hand to open or close the valve.

g. Do not tamper with safety devices in valves or cylinders.

h. Never force connections that do not fit.

i. Do not attempt to repair or alter cylinder or valves. Such repairs must be made by personnel who are trained for this purpose.

j. If a leak is discovered around a valve outlet, stem, or safety device, move the cylinder out-of-doors, open the valve, allow the gas to escape slowly, and keep personnel away. The valve will be tagged as defective and returned for repair.

k. When cylinders are placed in an upright position, take precautions to prevent then from being tipped over.

l. Do not permit oil, grease, paint, or other readily combustible substances to come in contact with cylinders, valves, connections, and fittings.

m. Never lubricate air valves, regulators, gages, or fittings with oil or grease.

n. Do not handle cylinders, valves, or connections with oily hands or gloves.

o. Do not permit cylinders to come in contact with any source of electricity.

3.3 PRECAUTIONS IN STORING CYLINDERS.

a. Protect cylinders against excessive rise or fall of temperature.

b. Cylinders may be stored in the open but in such case, protect then from extremes of weather and from the ground beneath to prevent rusting. During winter, protect cylinders stored in the open against accumulation of ice or snow. In summer, protect cylinders stored in the open from the continuous rays of the sun. Provide ventilation to keep temperature below 125°F.

c. Never store cylinders near flammable materials, especially fuels and oils.

d. Be careful to protect cylinders from any object that on contact could produce a cut, dent, or gouge in the cylinders.

e. Do not store cylinders in locations where heavy moving objects may strike or fall on them.

f. Do not expose cylinders to continuous dampness.

g. Never store cylinders near sources of electricity.

h. Always segregate EMPTY cylinders from full cylinders.

i. If valve protection caps become frozen, thaw them out in a warm room. Never use a heat source to quickly thaw them out because safety plugs may be melted.

j. Prohibit smoking wherever cylinders are stored.

3.4 PRECAUTIONS IN TRANSFERRING CYLINDERS.

a. Always close the cylinder valves and replace valve caps before moving cylinders.

b. Provide suitable hand trucks for moving cylinders and assure the cylinders are held securely in position on the hand trucks.

c. When necessary to move cylinders without a hand truck, always move the cylinders by tilting and rolling them on their bottom edges – never drag or slide a cylinder.

d. Never drop cylinders nor permit them to strike against each other. Keep them from being knocked over or from falling.

e. Do not use bars under valves or valve caps to pry cylinders loose when frozen or fixed to the ground.

f. Do not use an electric magnet or a sling to lift cylinders.

g. When cylinders are transported in trucks, railroad cars, and aircraft, secure them to prevent overturning or movement.

3.5 PRECAUTIONS FOR USE OF COMPRESSORS.

The air compressor shall be operated outside the contaminated area and shall be properly grounded. High-pressure lines shall be restrained to prevent whipping if line or connector breaks or line is accidentally disconnected. The compressor intake must not be located in areas where atmospheric pollution is occurring; e.g., near sewage manholes or sewage lift stations, engine exhausts, areas where toxic or noxious gases from any source are released into the atmosphere. There should be no unusual odor in the air where the compressor is operating.

CHAPTER 4
QUALITY CONTROL OF LIQUID BREATHING AIR

4.1 INTRODUCTION.

The quality control of liquid breathing air requires continuous surveillance. Surveillance begins with procurement of Air Force generation (manufacture) and continues throughout storage, handling, transfer, and servicing of the equipment. To assure mission completion, adequate and reliable quality control of liquid breathing air must be performed during each operation. The mixing instructions in Paragraph 4.8 through Paragraph 4.11 of this technical order do not apply to the mixing of liquid air in the TMU-23/5 portable storage tank.

4.2 PERSONNEL.

Personnel selected to perform operations in the supply system should be trained in a thorough knowledge of the characteristics of liquid breathing air, the effects of contamination when used for breathing purposes, and the supply system. Only those personnel who demonstrate understanding of the operations involved, and who are capable and reliable, should be assigned duties and responsibilities in the supply system.

4.3 OCCURRENCE.

Liquid air is normally obtained by mixing liquid oxygen and liquid nitrogen in the proper ratios.

4.4 PHYSICAL PROPERTIES.

Air may exist in the gaseous, liquid, or solid state dependent upon temperature and pressure. The following properties are for information only and will vary with changes in composition of the air.

Boiling point at atmospheric pressure	–318°F
Freezing range at atmospheric pressure	–357° to –364°F
Density	
liquid (–320°F)	53.7 lb/cu ft
gas (–320°F)	0.23 lb/cu ft
gas (70°F)	0.075 lb/cu ft

4.5 NOMENCLATURE.

The official nomenclature of the product, classified in FSC 6830, is air, liquid, for breathing purposes.

4.6 INTENDED USE.

The liquid breathing air covered by this technical order is intended for use in ground support applications such as self-contained breathing suit operations (Rocket Fuel Handler Clothing Outfit (RFHCO)).

4.7 REQUIREMENTS.

a. Procurement Limit – liquid breathing air procured from a commercial source must meet the requirements of the latest revision of NASA Specification SE-S-0073.

b. Blending limits for on-base synthesized liquid air. The liquid air in the newly mixed storage tanks shall be between 20 and 30% oxygen by volume minimum.

NOTE

Liquid nitrogen will evaporate faster than liquid oxygen; therefore, the percent oxygen in a newly mixed batch of liquid air should be less than 23%.

c. Use Limits – the liquid air in the storage tanks in active storage shall be between 20 and 30% oxygen by volume.

4.8 SOURCE OF LIQUID BREATHING AIR.

Liquid breathing air can be either blended locally or obtained from commercial sources. When local synthesis is desired, the liquid air shall be made up by mixing liquid oxygen conforming to MIL-PRF-27210 or MIL-PRF-25508 and liquid nitrogen conforming to MIL-PRF-27401 using the following instructions.

NOTE

If a TMU-27/M or a TMU-35/E Portable Storage Tank is used, refer to the applicable technical order for instructions on mixing and sampling.

4.9 PREPARATION.

a. One or more platform scales so arranged as to reliably weigh-in the desired total quantity of liquid air into the container shall be used. The scales platform shall be protected against liquid leakage

or spillage with a compatible blanket which does not impede the platform movement. A compatible blanket may be made up of a fluoroplastic sheet or film such as Teflon or Kel-F.

b. Teflon tape may be used to seal and attach the material as required. The transfer hoses shall be so arranged that they do not induce weighing error such as by resting on the ground adjacent to the scales. The hoses should suspended free from a fixed point away from the scales to the container to be filled on the scales.

4.10 DETERMINING MIXING QUANTITIES.

To determine the weigh-in quantities of liquid oxygen and liquid nitrogen to obtain a given quantity of liquid air, see Table 4-1. It is generally not feasible to mix quantities of less than 50 pounds of liquid air unless very accurate scales and precise control valves for controlling weigh-in quantity can be obtained.

4.11 HOW TO USE TABLE 4-1.

The desired mixing quantities may be determined by adding combinations of shown figures. For example: to mix a total of 128 liters of liquid air, add the digital sub-quantities to obtain the desired total quantity; then add the corresponding weights for both the liquid oxygen (liquid O_2) and liquid nitrogen (liquid N_2). If the scales are in pounds and ounces, convert total weights to the nearest ounce per Table 4-2. For example:

	Volumes	Lbs of liquid O_2	Lbs of liquid N_2
	100 liters	44.90	147.8
	20 liters	8.98	29.56
	8 liters	3.59	11.83
Total	128 liters	57.47 lbs	189.19 lbs
Converted Weights		57 lbs 7 oz	189 lbs 3 oz

4.12 FILLING.

The filling sequence shall be liquid oxygen and then liquid nitrogen. If several containers are to be filled, one after another, it is more economical to service all containers with liquid oxygen first and then service all containers with liquid nitrogen to the proper amount. To compensate for excess boil-off of a WARM system on the FIRST transfer of both liquid oxygen and liquid nitrogen, fill long by about 1 – 2% of the calculated weight for liquid oxygen, and fill short by about the same percentage of the calculated weight for liquid nitrogen. In mixing of small quantities of less than 500 pounds of liquid air, use the 2% off-weight. For quantities up to 2000 pounds of liquid air, use the 1% off-weight. Quantities of liquid air in excess of 2000 pounds should not require any weight compensation. Subsequent fillings when the system is cooled should be accomplished using the calculated quantities. Accurate transfer is very critical to proper proportions; however, methods of transfer do not easily lend themselves to accurate control. Therefore, the operator must exercise great care that the head pressure in the storage vessel from which product is being transferred is adequate, that the pressure building coils are adjusted to maintain an even pressure during transfer, and that the transfer shutoff valve is gradually closed as the correct weight is approached so as not to overshoot.

4.13 ON-BASE TESTING.

Each storage tank or mixing tank of liquid breathing air used at Air Force locations will be tested for percent oxygen as follows:

a. After Mixing – the liquid breathing air shall be allowed to stabilize for 24 hours after mixing prior to any sampling. After stabilization, a sample shall be taken to verify blending limits before the liquid air is used for breathing purposes.

b. Active Storage – the liquid air shall be sampled and tested within 24 hours to use.

4.14 SAMPLERS.

a. Sampler, MIL-S-27626, or one that is functionally equivalent.

b. Environmental Control Units (ECU) Titan II bases that have RFHCO suits authorized may use the ECU from the RFHCO as the sampler. (See Paragraph 4.17.)

4.15 ANALYZERS.

a. Oxygen Analyzer, Model D-2 Beckman Instrument Co., P/N 115583. (See Paragraph 4.17, Steps a and b for special instructions.)

b. Oxygen Analyzer, Mine Safety Appliance Co., P/N DF 87762.

NOTE

Purity of liquid breathing air may be performed by approved laboratories (Paragraph 2.12 and Paragraph 2.28) when the laboratory and the using activity are on the same base. The laboratory can use normal chemical laboratory procedures with an accuracy of at least 0.5% for analyzing the air.

Table 4-1. Quantities for Mixing Liquid Air (21% Oxygen – 79% Nitrogen by Volume)

To Make Up Total Quantity Liquid Air			Weigh-In	
			LO2	LN2
Gal	Liter	Lbs	Lbs	Lbs
		1	0.233	0.767
	1		0.449	1.478
		2	0.466	1.534
		3	0.699	2.301
	2		0.898	2.956
		4	0.932	3.068
		5	1.165	3.835
		2	1.347	4.434
		6	1.398	4.602
		7	1.631	5.369
1			1.700	5.595
	4		1.796	5.912
		8	1.864	6.136
		9	2.097	6.903
	5		2.245	7.390
		10	2.330	7.670
	6		2.694	8.869
	7		3.143	10.35
2			3.399	11.19
	8		3.592	11.83
	9		4.041	13.30
	10		4.490	14.78
		20	4.660	15.34
3			5.099	16.79
4			6.799	22.38
		30	6.990	23.01
5			8.498	27.97
	20		8.980	29.56
		40	9.320	30.68
6			10.20	33.57
		50	11.65	38.35
7			11.90	39.16
	30		13.47	44.34
8			13.60	44.76
		60	13.98	46.02
9			15.30	50.35
		70	16.31	53.69

Table 4-1. Quantities for Mixing Liquid Air (21% Oxygen – 79% Nitrogen by Volume) - Continued

To Make Up Total Quantity Liquid Air			Weigh-In	
			LO2	LN2
Gal	Liter	Lbs	Lbs	Lbs
10			17.00	55.95
	40		17.96	59.12
		80	18.64	61.36
		90	20.97	69.03
	50		22.45	73.90
		100	23.30	76.70
	60		26.94	88.69
	70		31.43	103.5
20			33.99	111.9
	80		35.92	118.3
	90		40.41	133.0
	100		44.90	147.8
		200	46.60	153.4
30			50.99	167.9
40			67.99	223.8
		300	69.90	230.1
50			84.98	279.8
	200		89.80	295.6
		400	93.20	306.8
60			102.0	335.7
		500	116.5	383.5

4.16 PROCEDURES.

4.17 SAMPLING AND TESTING USING ENVIRONMENTAL CONTROL UNITS (ECU) AND BECKMAN MODEL D-2 ANALYZER.

One ECU shall be filled in accordance with T.O. 37C2-3-5-1.

WARNING

The ECU selected for sampling and testing shall not contain any residual liquid air from previous operations.

a. The D-2 will be operated in accordance with T.O. 33A7-8-4-1 except for correction factors in Paragraph 3 and Section 4.

Table 4-2. Conversion — Decimal Pounds to Ounces

For Decimals From – Thru		Use Ounces
0.00	0.03	0
0.04	0.09	1
0.10	0.16	2
0.17	0.22	3
0.23	0.28	4
0.29	0.34	5
0.35	0.40	6
0.41	0.47	7
0.48	0.53	8
0.54	0.59	9
0.60	0.66	10
0.67	0.72	11
0.73	0.78	12
0.79	0.84	13
0.85	0.90	14
0.91	0.96	15
0.97	1.00	16

b. A correction factor for the D-2 will be computed prior to each analysis as follows:

(1) Draw ambient air into D-2 (squeeze and release aspirator bulb minimum of 12 times).

(2) Read and record this value for ambient air.

(3) Subtract this value from 21.0% to obtain correction factor.

c. Obtain a 1-inch rubber stopper and place on the end of the D-2 sampling tube.

d. Place airtight cap over recirculating secondary air inlet.

e. Open ECU pressure and flow initiator valves and allow system to purge for a minimum of 30 seconds.

f. Connect the D-2 sampling tube to the ECU conditioned air outlet (insert stopper in ICU's outlet tube).

g. Obtain an air sample (squeeze and release aspirator bulb minimum of 12 times).

h. Close the ECU pressure and flow initiator valves.

i. Disconnect the D-2 sampling tube from the ECU conditioned air outlet (remove stopper from outlet tube).

j. Read and record the value for the sampled air.

k. Add or subtract the value obtained in Step b (3) above to the value in Step j.

l. Record the corrected value for percent oxygen.

4.18 EXAMPLES OF CORRECTION FACTOR CALCULATION FOR MODEL D-2 OXYGEN ANALYZER.

a. If the value obtained in Paragraph 4.17, Step b (2)for ambient air is less than 21.0%, the difference between 21.0 and the ambient air reading is added to the value obtained in Paragraph 4.17, Step j.

b. If the value obtained in Paragraph 4.17, Step b (2)for ambient air is greater than 21.0%, the difference between 21.0 and the ambient air reading is subtracted from the value obtained in Paragraph 4.17, Step j.

c. If the value obtained in Paragraph 4.17, Step b (2)is equal to 21.0%, no correction is required.

4.19 MINE SAFETY APPLIANCE OXYGEN ANALYZER.

Using Mine Safety Appliance Oxygen Analyzer in accordance with T.O. 33C2-17-1 or laboratory procedures to analyze air from the ECU follow the steps in Paragraph 4.17, Steps c through j.

4.20 SAMPLING AND TESTING USING SAMPLER MIL-S-27626 OR EQUIVALENT.

Liquid air samples shall be taken using the applicable sampler technical order.

a. Using Beckman Model D-2 analyzer:

(1) The D-2 will be operated in accordance with T.O. 33A7-8-4-1 except for correction factors on Page 1, Paragraph 3 and Section 4.

(2) A correction factor for the D-2 will be computed prior to each use as follows:

(a) Draw ambient air into D-2 (squeeze and release aspirator bulb minimum of 12 times).

(b) Read and record this value for ambient air.

(c) Subtract this value from 21.0% to obtain the correction factor.

(3) Attach a plastic, rubber, or metal tubing (about 6 inches long) to the sampler or sample cylinder outlet port.

(4) Crank open the outlet port valve until a slight flow of air can be felt at the end of tubing.

(5) Slide the analyzer sampling tube as far as it will go into the larger tubing.

(6) Obtain an air sample (squeeze and release aspirator bulb minimum of 12 times).

(7) Close the outlet port valve.

(8) Read and record the value for sampled air.

(9) Add or subtract the value obtained in Step a (2) (c) to the value obtained in Step a (8).

(10) Record the corrected value for percent oxygen.

b. Using Mine Safety appliance Oxygen Analyzer in accordance with T.O. 33C2-17-1 and follow Steps a (3) through (8).

c. Using laboratory procedures, attach sampler MIL-S-27626 or equivalent to the test equipment.

4.21 REJECTION DUE TO TEST FAILURE.

When the percent oxygen in the storage tank in active storage exceeds 30% oxygen, the liquid air shall be drained and the unit be recycled for refilling.